Mice and Voles Prefer Spruce Seeds

by
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Study in Maine suggests an explanation for the predominance of balsam fir seedlings in regeneration

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by Herschel G. Abbott and Arthur C. Hart

WHEN spruce-fir stands in the Northeast are cut, balsam fir seedlings often predominate in the regeneration that follows. Most landowners would prefer to have the spruce; but they do not get it, and they wonder why.

Recently-completed studies lead us to believe that the reason may lie in the feeding habits of mice and other small mammals: they definitely reject the balsam fir seeds, but eat the spruce seeds. This would keep down the proportion of spruce in the new stand of seedlings.

Our attention was drawn to the small seed-eating mammals several years ago, in connection with research into the silviculture and management of spruce-fir stands on the Penobscot Experimental Forest near Bangor, Maine. In 1953 a census was made on the Forest in an attempt to learn something of the population density of such animals. The mouse and vole population was found to average nearly 12 animals per acre, and the predominant species was the red-backed vole.[1] (Voles are commonly called

[1]Grisez, Ted J. Results of a mouse census in a spruce-fir-hemlock stand in Maine. Northeast. Forest Expt. Sta. Forest Res. Note 28. 2 pp., 1954.

mice, though they differ from true mice in several morphologica characteristics.)

Recent laboratory studies of tree seed consumption have estab lished the relative preferences of mice and voles for seeds of re spruce, white spruce, and balsam fir.[2] These tests have show that these small mammals reject balsam fir seed in favor of spruc seed.

In the fall of 1959 a study was begun on the Penobscot Fores in an attempt to determine the preferences of these small seed eating mammals under field conditions. This is a report on thi study.

The Study Areas

Two 1-acre areas about 20 chains apart were used for th study. Both areas were in mature softwood stands on wel drained, stony silt loam soils. About half of the stand volum was eastern hemlock. The remainder was red and white spruc northern white-cedar, balsam fir, red maple, and paper birch.

Area 1 was located in a stand that had been selectively cut i 1954, removing 26 percent of the original volume. Area 2 wa in a stand selectively cut in 1955, removing 19 percent of th original volume. The logging operations left small openings i the canopy; and scattered debris consisting of bark, limbs, an tops from the cut trees remained on the ground. A logging roa and a bucking yard bordered the southern edge of Area 1. A log ging road also passed diagonally through the northwestern por tion of Area 2, and another passed within half a chain of th southern border. Both areas contained excellent cover for sma mammals.

There was no seed crop of balsam fir on either area in 19 and only a very light crop of spruce seed.

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[2]Abbott, Herschel G. Tree seed preferences of mice and voles in the North Manuscript accepted for publication by JOURNAL OF FORESTRY.

Procedure

In this study the animals were allowed free access to known weights of balsam fir and white spruce seed exposed in specially constructed two-compartment feeders during September and October 1959. Six feeders were located in each study area. Before seeds were exposed, a small-mammal census was taken by live-trapping to determine species and numbers of animals present on each area. At the completion of the study, a final census was made by snap-trapping the animals assumed to be responsible for taking seeds from the feeders.

Small Mammal Census

The pre-feeding census was started on both areas on September 1, using Sherman live traps. Twenty-five traps were set out in a grid pattern 40 feet apart on each area. Trap spacing followed the recommendations of Burt[3] and Quick[4]. Stakes, marked to show trap line and trap number, were established at each trapping point on the grids. One trap was then set at the most suitable location within a 5-foot radius of each stake. The traps, located insofar as possible in the immediate vicinity of rocks, stumps, fallen trees, slash, and other debris that offered cover, were baited with a mixture of peanut butter, rolled oats, raisins, and bacon grease. They were checked daily between 8 and 9 a.m.

Captured animals were identified by species, marked by clipping the nail of the second toe of the right hind foot, and released. Trapping was continued on successive nights until no unmarked animals were taken. This required 5 nights on Area 1 and 11 nights on Area 2.

The initial small-mammal population on Area 1 consisted of 9 red-backed voles (*Clethrionomys gapperi*) and one deer mouse (*Peromyscus maniculatus*). The population on Area 2 consisted of 19 red-backed voles, 2 deer mice, and 5 masked shrews (*Sorex cinereus*) (table 1).

[3]Burt, William H. Territorial behavior and populations of some small mammals in southern Michigan. Univ. Mich. Mus. Zool. Misc. Pub. 45: 1-58, 1940.
[4]Quick, Horace. Small mammal populations on the University forest. Univ. Maine Forestry Dept. Tech. Note 28, 2 pp., 1954.

Area 2 was trapped initially during the same 5-day period a Area 1. With the exception of one station, a different lot o Sherman live-traps were used on each area. One extra trap fro the lot used in Area 1 was set at Station 2-2 in Area 2. For som undetermined reason, the only captures (3 animals) on Area during the initial 5-day period were made in this trap.

Table 1. — *Small mammal census data: numbers of mice an voles on study areas*

Census	Area 1		
	Clethrionomys	*Peromyscus*	Total
Pre-feeding (live trapping)	9*	1	10
Post-feeding (snap trapping)	20	12	32

Census	Area 2			
	Clethrionomys	*Peromyscus*	*Sorex*	Tota
Pre-feeding (live trapping)	19**	2	5***	26
Post-feeding (snap trapping)	6	11	0	17

*One died in handling.
**Two died in live-traps.
***All died in live-traps.

The two lots of traps were similar in size, shape, and co struction, yet the traps used on Area 2 were completely ineffecti Therefore, at the end of the initial trapping period, all tra were removed from both areas, and those traps previously set Area 1 were reset in Area 2. This second trapping period w continued for six consecutive nights until no unmarked anim were captured. This trapping was successful and produced additional 23 animals.

Seed Exposure

Each feeder consisted of a base, containing two seed trays, and a hinged top. Top and base were each 16 inches square and 3 inches deep. The seed trays, approximately 7 x 14 inches outside measurement and 3 inches deep, were supported by two slats nailed to the bottom of the base (fig. 1). Copper screening was used for the bottoms of the seed trays. But since 18 x 14 mesh would allow some small spruce seeds to pass through, the screening used on the trays for spruce seed was stretched diagonally at time of installation to reduce the mesh size.

Figure 1. — *Feeder in place, with top open to show trays and seed. One tray contained balsam fir seed, the other spruce seed.*

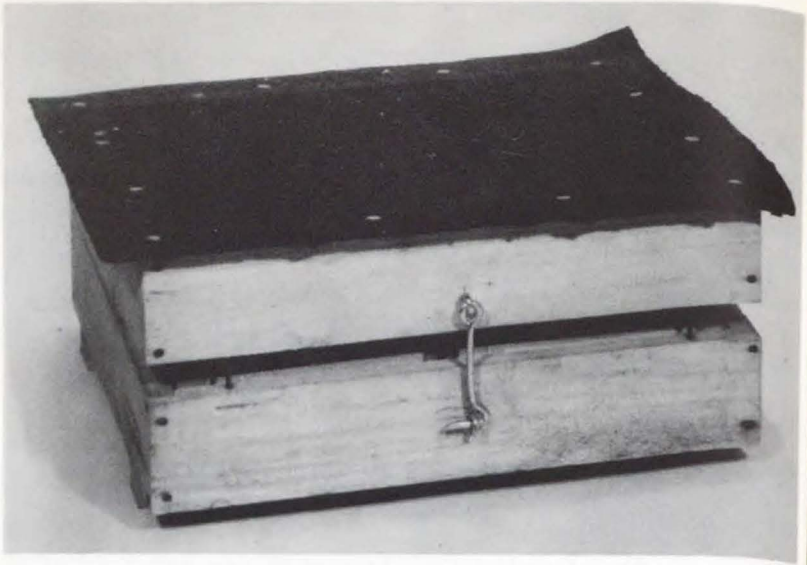

Figure 2. — *Feeder in set position. The 3/4-inch opening lets the small animals in but keeps larger animals and birds out.*

The feeder top was also covered with 18 x 14 mesh copper screening; and a piece of roofing paper was nailed over the top to keep the seed dry. Stops and hook fasteners were used at the front of the feeders to maintain a 3/4-inch opening between the base and the top; this was to let the small animals in, but to keep larger animals and birds out (fig. 2).

Cutting tests showed that 96 percent of the white spruce seed and 36 percent of the balsam fir seed was sound. The spruce seed tested 99 percent in purity, with 186,180 seeds per pound; the fir was 95 percent pure, with 69,180 seeds per pound. All seed for the study was weighed and packaged in 1-ounce units before the feeding tests were begun.

The feeders were placed near the most productive trapping stations on each area. They were put out in Area 1 on September 6 and in Area 2 on September 12. Each feeder was supplied with 1 ounce of white spruce seed and 1 ounce of balsam fir seed, each in its respective tray.

The seed supply was replenished daily or as needed, the amount depending on the quantity of seed consumed during the

preceding 24 hours. A record was maintained of the amount of seed supplied to each feeder. At intervals, the residue was removed and analyzed for uneaten seeds to determine the actual amounts consumed or removed. Feeding was continued on both areas until October 11, when the supply of spruce seed available for the study was exhausted.

Census After Seed Exposure

On October 12, immediately after termination of the seed-exposure period, a final small mammal census was taken. Three snap traps were set at each of the 25 trapping stations on each area. At each station, one trap was baited with a mixture of peanut butter and rolled oats, a second trap with bacon grease, and the third with raisins. Trapping was conducted for three consecutive nights, and daily records of results were kept (table 1).

In Area 1, 20 red-backed voles and 12 deer mice were caught, while on Area 2 only 6 voles and 11 deer mice were captured. All 49 animals were caught in the first two nights of trapping, and 43 of them were caught during the first night.

An item of no obvious significance in the experiment, but of general biological interest, was the sex ratios among these animals. For the deer mice, the ratio of males to females was 1 to 1.4 on Area 1, and 1 to 0.4 on Area 2. For the voles, the ratio was 1 to 9 on Area 1, and all females on Area 2.

Amount of Seed Consumed

The small-mammal population on the two areas consumed 25.75 pounds (412.05 ounces) of white spruce seed and 1.01 pounds (16.10 ounces) of balsam fir seed (table 2). This indicates a preference ratio of 25.5 to 1 in favor of spruce over fir, based upon the weight of commercially-clean seed.

Table 2. — *Quantity of commercially clean seed exposed and consumed or removed by small mammals, in ounces*

Item	Area 1		Area 2		Total	
	Spruce	Fir	Spruce	Fir	Spruce	Fir
Seed exposed	259.00	12.00	156.00	12.00	415.00	24.00
Seed recovered in residue	1.51	3.57	1.44	4.33	2.95	7.90
Seed actually consumed or removed	257.49	8.43	154.56	7.67	412.05	16.10

However, this ratio is somewhat unrealistic because of the difference between the percentages of sound seed in the two seed lots. When the consumption figures are adjusted to represent the weight of only *sound* seed consumed, it is found that 24.47 pounds of white spruce seed and 0.35 pound of balsam fir seed were consumed. The preference ratio of spruce to fir is thus increased to 70 to 1.

The relative consumption of different kinds of seeds may be greatly influenced also by their availability. In this study, no balsam fir seed was eaten or removed as long as white spruce seed was available in the same feeder. The fir seed went untouched on both areas from the date of first exposure until the weekend of September 26 and 27. On this weekend, the feeders were not tended and the supply of spruce seed was exhausted. Apparently it was only under these conditions that the mice were interested in the fir seed.

Since there was no natural seed crop of balsam fir seed and only a very light crop of spruce seed on the study areas, seed availability, for all practical purposes, was limited to the seed offered in the feeders.

On September 30, consumption of spruce seed began to show a marked increase (fig. 3), so the amount of seed exposed in each feeder was increased from 1 ounce to 2 ounces. It was at this time that the second replenishment of balsam fir seed was

made—1 ounce in each feeder. The following day the supply of white spruce seed was increased to 3 ounces. Even this quantity was not adequate to satisfy the demands of the mice; so, on October 2, 4 ounces of seed were placed in each feeder. From this time on, 4 ounces were added as needed until October 11, when our supply of spruce seed was exhausted.

In comparing seed consumption between areas, we found little difference in the amounts of fir seed consumed (8.43 ounces on Area 1 versus 7.67 ounces on Area 2).

Consumption of spruce seed, however, was much greater on Area 1 than on Area 2: 257.49 ounces versus 154.56 ounces. This difference probably was due to the greater number of mice on Area 1. On the basis of the post-feeding census (table 1), 32 animals were feeding on Area 1, as compared to 17 on Area 2, during the latter part of the test period when the sharply accelerated seed consumption occurred. Consumption of spruce seed

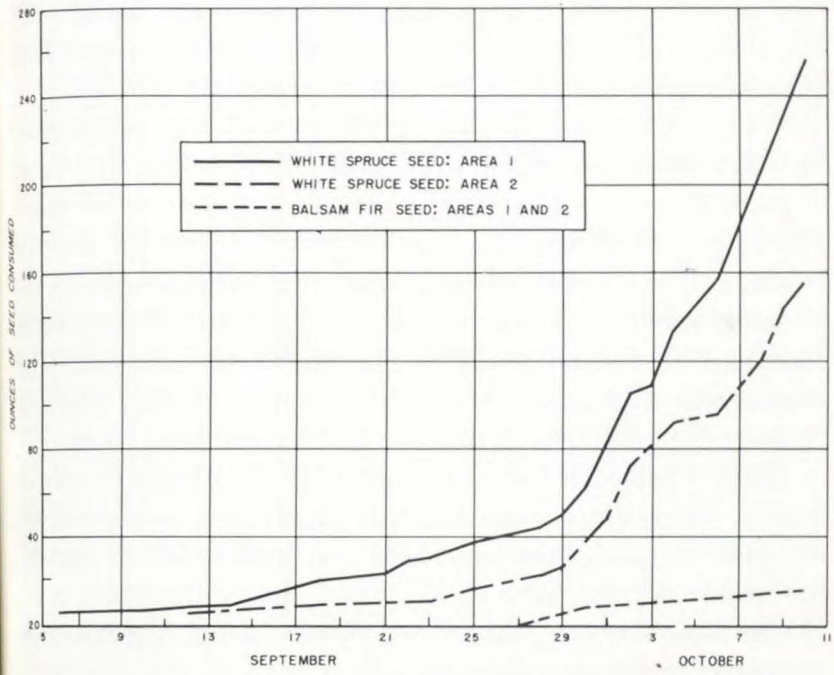

Figure 3. — *Cumulative consumption of white spruce and balsam fir seed.*

per animal for the entire test period—again on the basis of the post-feeding census—averaged 8.04 ounces on Area 1 and 9.09 ounces on Area 2. This difference possibly is related to the differing proportions of *Clethrionomys* and *Peromyscus* in the two populations (table 1).

In comparing seed consumption on the two areas, a minor detail to note is that the feeding period was started 6 days earlier on Area 1 than on Area 2. However, this had little influence on the total results, as only 3 ounces of spruce seed were consumed on Area 1 during the initial 6-day period.

Discussion

The fact that balsam fir seed was consumed in this study only when spruce seed was not available supports previous observations by Abbott that *Clethrionomys* and *Peromyscus* prefer spruce seed over balsam fir seed. The sharp increase in seed consumption beginning about October 1, or 3 to 4 weeks after seed was first placed in the feeders, was of particular interest. Such an increase in seed consumption might come about in two ways: (1) from an increase in number of animals present, or (2) from increased activity by animals already present in removing seed for storage.

The authors believe that the increased consumption in this case primarily reflects increased seed removal for storage. Considerable mouse activity was noted at this time, and it was not unusual to observe mice visiting the feeders during daylight hours. The best evidence, however, was in the fact that the amount of seed-coat residue left in the feeders became progressively smaller in several feeders during this period. A similar observation on the storage of white pine seed, based upon seed coat residues left in feeders, has been made by Abbott.[5] He found that white-footed mice (*Peromyscus leucopus*) and red-backed voles stored approximately 50 percent of the seeds removed.

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[5]Abbott, Herschel G. White pine seed consumption by small mammals. JOUR. FORESTRY 59: 197-201. 1961.

The seed-storage theory is further supported by the fact that the patterns of increased consumption on the two areas in early October were similar, whereas, according to the census data (table 1), changes in the mouse-vole populations during the test period were markedly dissimilar (increasing from 10 to 32 on Area 1, decreasing from 21 to 17 on Area 2). The increased consumption thus seems clearly to reflect a change in the activities of the animals that is unrelated to population changes. The logical assumption is that the animals rather abruptly entered a phase of seed-storage activity.

The cumulative seed consumption shown in figure 3 and the consumption totals in table 2 provide a quantitative picture of spruce seed losses of a magnitude that might substantially influence spruce regeneration. The data show that a mixed population of 15 to 30 red-backed voles and deer mice per acre possesses a consumption potential for spruce seed far exceeding the amount normally produced in natural seed crops.[6] Our study was terminated during the peak of storage activities by the animals, so we have no measure of the amount of seed they could have taken. However, in a 5-week period they had already taken some 13 pounds of spruce seed per acre, almost 10 pounds of which they took in less than 2 weeks of intensive storage activity.

Naturally disseminated seed on and in the forest floor undoubtedly would not be found and removed as rapidly as the freely accessible seed in the feeders. However, the capacity for consuming much more seed than natural crops provide, coupled with the marked preference shown for spruce seed, suggests that the animals may be largely responsible for the low ratio of spruce to fir seedlings commonly found under spruce-fir stands in the Northeast.

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[6]The spruce seedfall per acre in 8 softwood stands on the Penobscot Experimental Forest in 1953, when both red and white spruce trees produced heavy cone crops, ranged from 145,000 to 1,529,000 seeds per acre, with an average of 818,000. Assuming an average of 190,000 seeds per pound, these figures convert to 0.75 to 8 pounds, averaging 4.3 pounds per acre on the 8 areas sampled.

Summary

A study conducted on the Penobscot Experimental Forest near Bangor, Maine, during September and October 1959, dealing with the relative consumption of white spruce and balsam fir seed by small mammals showed that:

- The animals present (red-backed voles and deer mice) exhibited a definite preference for spruce seed.
- They ate balsam fir seed only when spruce seed was not available.
- Large quantities of spruce seed apparently were stored in addition to the amount eaten.
- The daily rate of seed consumption was not constant but showed a rapid increase starting about October 1, 3 weeks after the study was begun. This trend is believed to be associated with seed storage.
- Approximately 26 pounds of spruce seed were eaten or stored in a 5-week period by the mice and voles on two 1-acre plots.
- The number of animals presumably responsible for destroying this quantity of seed was 49 (26 red-backed voles and 23 deer mice).
- Spruce seed consumption per animal for the 5-week period averaged 8 to 9 ounces.

Acknowledgment

The spruce seed used in this study was contributed by the Maine Forest Service through Forest Commissioner Austin Wilkins. Dr. Horace Quick and Dr. Sanford Schemnitz of the University of Maine School of Forestry assisted in gathering the small-mammal population data.

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